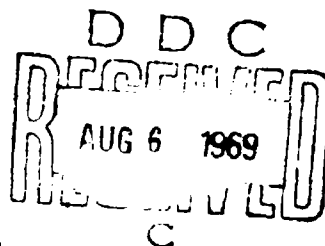
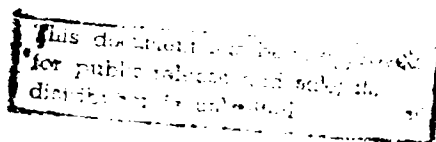


**ISOLATION: THE MAJOR BARRIER TO THE INTELLECTUAL  
CROSS-FERTILIZATION OF SCIENTIFIC PERSONNEL IN AN  
AIR FORCE-INDUSTRY RESEARCH AND DEVELOPMENT PROGRAM**

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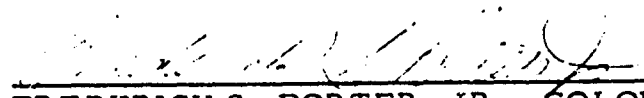
## FOREWORD

This paper was presented by the author at the 7th Annual, Region III, IEEE Convention at Cocoa Beach, Florida held November 18-20, 1968.

Publication of this paper does not constitute Air Force approval of its contents, findings or conclusions. It is published only for the exchange and stimulation of ideas.

  
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## ABSTRACT

Intellectual cross-fertilization is defined as the mutual technical enrichment that occurs as a result of lateral communication among scientists and engineers. In an Air Force sponsored-industry conducted research and development program intellectual cross-fertilization promotes the cost effective utilization of scientific and engineering talent. The isolation of technical personnel, since it prevents lateral communication, is identified as the principal barrier to intellectual cross-fertilization. Potential solutions for removing various segments of this barrier are examined.

The communication process in its simplest form involves the transmission and reception of an idea from one person to another. The essential elements of this process are a transmitter, a message (ideas, words, actions), a receiver and feedback (i. e. knowledge that the message was received and understood.) The transmission and reception of a message may stimulate additional, possibly unrelated, thought processes. When the communication process stimulates this secondary intellectual activity on the part of the receiver, the transmitter or both, such that new light has been shed on old problems or new concepts have been discovered, intellectual cross-fertilization is said to have occurred. Intellectual cross-fertilization often results in the mutual enrichment of both parties involved in the communication process. Thus through frequent cross-fertilizations intellectual potentials become intellectual actualities, thereby promoting maximum utilization of an individual's capabilities.

Extrapolating this concept to an Air Force sponsored-industry conducted research and development program, intellectual cross-fertilization may be defined as the mutual technical enrichment of scientific personnel that occurs as a result of lateral communication among scientists and engineers. Scientific personnel are considered here to be persons who possess a formal degree in some scientific or engineering discipline. In the situation under study the transmission of technical messages stimulates secondary intellectual activity. This secondary intellectual activity often results in the solution of a previously insurmountable problem or the discovery of an entirely new approach to an existing problem.

Intellectual cross-fertilization is intimately associated with the communication process. Therefore, the factors that hinder or prevent effective lateral communication among the scientific and engineering personnel of an Air Force-industry research and development program may also prevent successful technical cross-fertilization.

According to Redfield (1958), the majority of management surveys indicate that the most serious difficulties in business communications arise in the area of horizontal or lateral communication. Poor lateral communication among scientists and engineers can result in the duplication of effort, inordinate schedule delays, waste of large sums of money and negligible or limited intellectual cross-fertilization.

This paper will investigate how the isolation of scientific personnel prevents lateral communication and is therefore a major barrier to intellectual cross-fertilization. It can be shown that the limitation or prevention of cross-fertilization diminishes the degree to which technical personnel can be effectively utilized. Needless to say, the non-utilization of scientific talent is a costly waste of the research and development program's resources.

For the purposes of this investigation it is assumed that the lateral communication process has ideal transmitters and receivers. That is, neither the sender of a message nor the receiver has personal deficiencies which prevent or impair the transmission of information. The sender can and does transmit his information with clarity and accuracy. The receiver wants to receive this information and is capable of understanding it. Based on these conditions, the isolation of scientific personnel, preventing lateral communication, is chiefly a function of the transmission medium. That transmission medium is simply the communicative universe in which the lateral communication occurs.

For an Air Force-industry research and development program the communicative universe consists of three basic elements: (1) the System Program Office (SPO) organization in the Systems Command of the United States Air Force; (2) the industrial concern's engineering organization; and (3) an external environment composed of such entities as academic affiliations and professional associations.

## BASIC ELEMENTS OF THE COMMUNICATIONS PROCESS

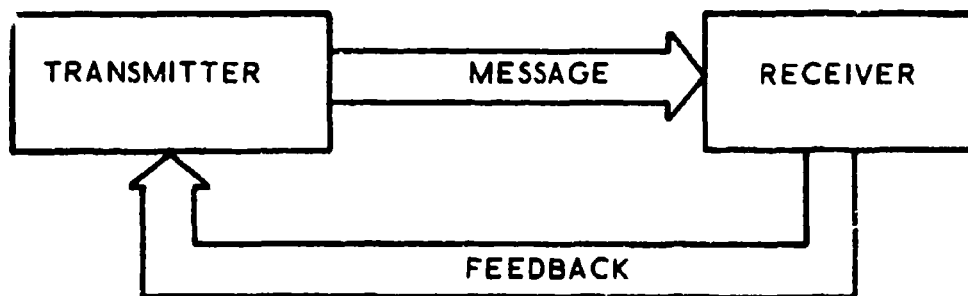


Figure 1. Basic Elements of the Communication Process.

The Air Force Systems Command engages in systems management under the provisions of the Air Force Systems Command manuals in the 375 series. The objectives of systems management is to specify, acquire and temporally integrate the hardware, computer programs, facilities, personnel, training and procedural data necessary to meet Air Force system requirements. To help achieve this objective the Air Force Systems Command created the System Program Office (SPO) organization, which is illustrated in Figure 2.

The Engineering Division of the SPO organization is directly responsible for the system engineering management effort. This responsibility includes the definition of the criteria required to fulfill the project objectives and the development of performance, design and test requirements. The successful fulfillment of these responsibilities demands good lateral communication between the Engineering Division of the SPO organization and the industrial concern's engineering staff.

Frequently, according to Terry (1961), an industrial concern will form a line and staff organization to facilitate the flow of information in its engineering organization. The information flow in a typical engineering line and staff organization is depicted in Figure 3.

The lateral communication paths, which might permit intellectual cross-fertilization among scientific personnel, are established by the communicative universe of the research and development program. Four basic channels of lateral communication are open to company scientists and engineers: (1) to other engineers and scientists in the company, (2) to middle management engineers, (3) to the Air Force System Program Office, and (4) to the academic-professional world. (See Figure 4)



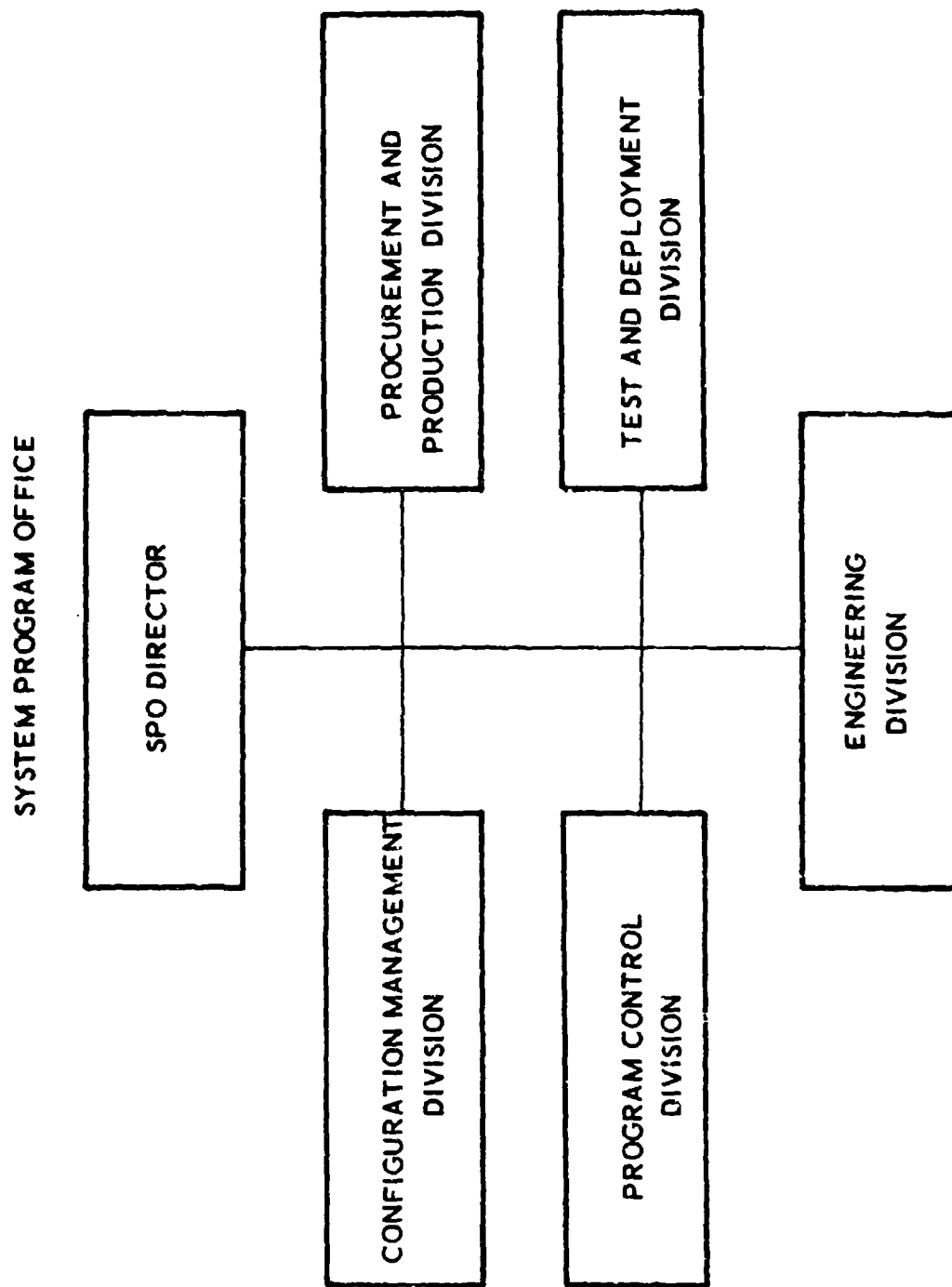


Figure 2. The System Program Office (SPO) Organization in the Systems Command of the United States Air Force.

## ENGINEERING LINE AND STAFF ORGANIZATION

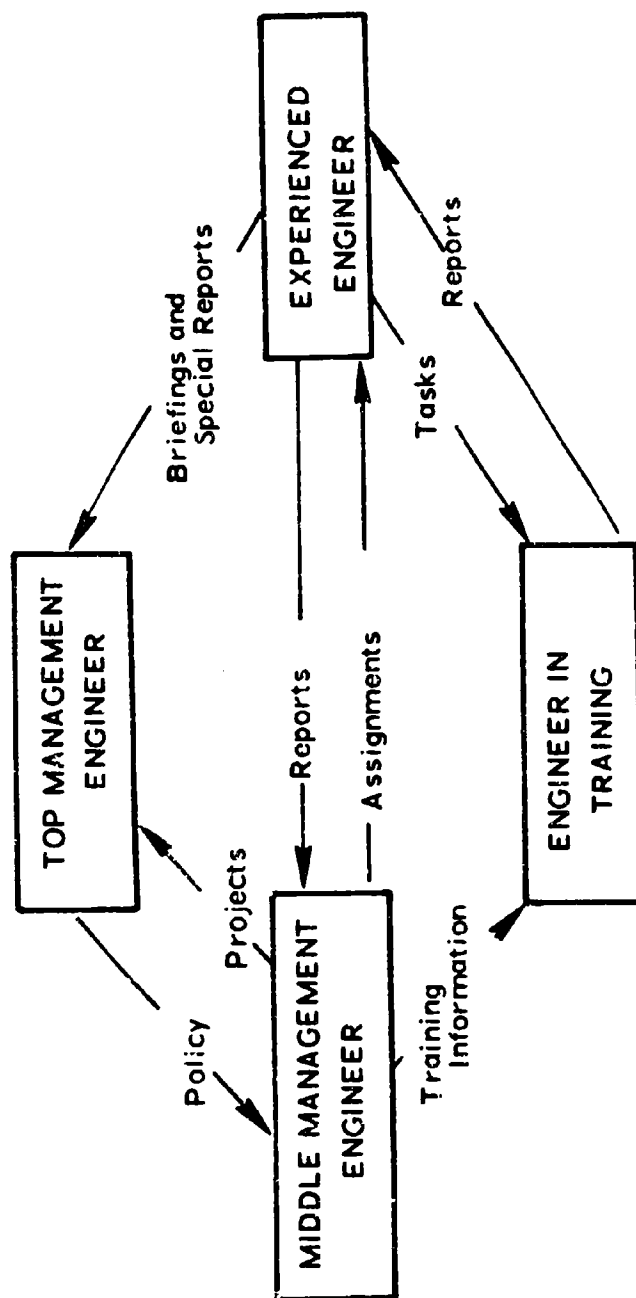


Figure 3. Information Flow in an Engineering Line and Staff Organization, Terry (1961)

# PATHS FOR LATERAL COMMUNICATION

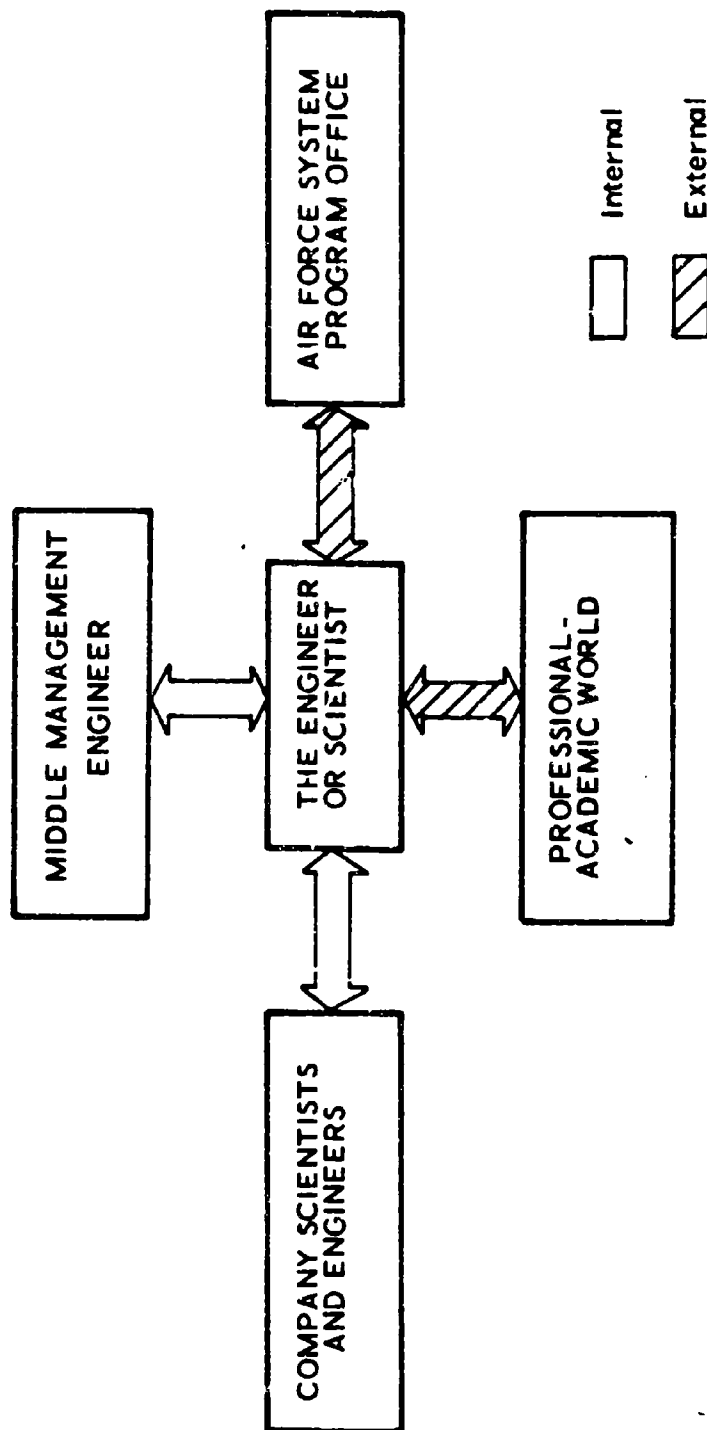


Figure 4. Lateral Communication Paths that are open to Scientific Personnel in an Air Force-Industry R & D Program.

The isolation of scientific personnel may form the major barrier which prevents effective intellectual cross-fertilization. This paper will not discuss those components of the isolation barrier, such as security restrictions and geographical location, which are clearly beyond the control of the individual communicants. Rather, it will treat those components of the isolation barrier that can be influenced and controlled by the individuals, participating in lateral communication. Under these conditions the isolation of scientific personnel is either internal, involving the intra-company paths of lateral communication, or external, involving the lateral communication paths which connect the scientist or engineer to the Air Force System Program Office or to the academic-professional world. (See Table 1)

There are two major types of internal isolation: (1) the isolation of objectives and (2) information isolation.

The isolation of objectives occurs when a middle management engineer fails to clearly define the objectives of a particular job assignment for the company's experienced engineering personnel. As a result the company engineer does not have the objectives of management (for example cost reduction or rapid completion of assignment) as a guide from which technical decisions and design trade-offs can be made. In addition the middle management engineer cannot be informed of those technical alternatives and approaches which might influence management's objectives. Under these circumstances productive intellectual cross-fertilization becomes impossible. To overcome the objectives isolation barrier, it is necessary to progressively refine information as it flows through the engineering organization. One way to insure refinement of information is to conduct frequent meetings, geared toward the establishment of strong lines of lateral communication between engineering management and the technical staff. These meetings can range from formal presentations to informal

**COMPONENTS OF THE ISOLATION BARRIER THAT ARE UNDER  
THE CONTROL OF THE COMMUNICANTS:**

**INTERNAL**

- 1) **THE ISOLATION OF OBJECTIVES**
- 2) **INFORMATION ISOLATION**

**EXTERNAL**

- 3) **ORGANIZATIONAL ISOLATION**
- 4) **INTELLECTUAL ISOLATION**

Table 1. Components of the Isolation Barrier that are under  
the Control of the Communicants.

luncheons, but their net effect should be the same: to foster effective cross-fertilization. The engineer or scientist will become aware of management's objectives and engineering management will be exposed to new technical approaches and novel alternatives for the solution of existing problems.

Information isolation may occur when the engineer or scientist is cut off from valuable information in the technical literature. Lateral communication by means of the technical literature is an indirect process in which the transmitter (author) conveys his message to the receiver (reader) with the printed word serving as a transmission medium. Feedback does not occur in real time and cross-fertilization in the strictest sense does not occur. However, the engineer or scientist may receive sufficient intellectual stimulation from a technical publication such that secondary thought processes are produced. When this happens, one way intellectual fertilization can be said to have occurred. If the technical article provides a sufficiently strong intellectual stimulus, the reader may be urged to generate written comments of his own. If these comments are then forwarded to the original author, a feedback loop is established and non-real time cross-fertilization occurs. Information isolation can be caused by the vast volume of technical literature available or by the tendency of an individual or office to pigeonhole information and prevent its circulation. In the former case constant literature searches by the scientist or engineer for needed information are costly and time consuming processes, which are often made impossible by the volume of data available. The latter cause of information isolation often promotes duplication of effort or delay in task completion. As a result of either cause the scientist or engineer is denied access to information in the technical literature and indirect lateral communication does not occur.

To eliminate the information isolation barrier, the company can establish science libraries with specialized technical staffs who procure,

sort, route and file the vast quantity of scientific information available in the literature. Individual offices can eliminate information isolation by enforcing rigid routing procedures which insure that the appropriate scientific personnel are exposed to relevant technical information as soon as it becomes available.

This paper will now discuss the components of the isolation barrier which involve lateral communication paths outside the company. There are two major types of external isolation: (1) organizational isolation and (2) intellectual isolation.

Organizational isolation occurs when the intermediate layers of management or company policy itself completely cut off the engineer or scientist from association with the Engineering Division of the Air Force System Program Office. Many times the company engineer can gain a broader view of the overall problem, if he is allowed to participate directly in a discussion with SPO personnel. The Air Force personnel responsible for engineering management are exposed to the technical particulars of the program and can utilize this information in shaping its ultimate form. To overcome organization isolation and to promote effective lateral communication between company and Air Force scientific personnel, direct participation by the company engineers and scientists in formal Air Force-contractor meetings is to be encouraged. Informal working group meetings provide an even better opportunity for lateral communication and should be held as frequently as possible to foster a maximum amount of cross-fertilization among the two organizations.

Finally, the engineer or scientist can experience intellectual isolation. This occurs when the individual has been separated for a long period of time from the contemporary technical thoughts of the academic-professional world. This component of the isolation barrier can be eliminated and the lateral

communication process enhanced by encouraging the engineer or scientist to publish technical reports, attend professional meetings and symposia, maintain strong personal contacts in the academic world and keep in frequent contact with professional associates outside the company.

In summary, the isolation of scientific personnel in an Air Force-industry research and development program may prevent effective lateral communication and is therefore a major barrier to intellectual cross-fertilization. The most significant components of this barrier, which are under the influence or control of the communicants, have been discussed and potential solutions for their removal or negation offered. Intellectual cross-fertilization promotes an effective utilization of engineering and scientific talent and should be pursued to insure maximum use of a program's resources.



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